CITY OF SYDNEY

RUSHCUTTERS BAY CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

FINAL

wma water

APRIL 2016

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
Fax: 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

RUSHCUTTERS BAY CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

FINAL REPORT

APRIL 2016

Project Rushcutters Bay Catchment Floodplain Risk Management Plan	**Project Number** 114014
Client City of Sydney	**Client's Representative** Shah Alam
Authors Felix Taaffe Steve Gray	**Prepared by** 
Date 21 April 2016	**Verified by** 

Revision	Description	Distribution	Date
4	Final	Shah Alam	Apr 2016
3	Draft Final		Dec 2015
2	Draft Plan - Revised		Apr 2015
1	Draft Plan		Feb 2015

RUSHCUTTERS BAY CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

TABLE OF CONTENTS

PAGE

FOREWORD ..... **i**

EXECUTIVE SUMMARY ..... **ii**

1. FINDINGS OF FLOODPLAIN RISK MANAGEMENT STUDY **1**

1.1. Background 1

1.2. Flood Hazard Classification 1

1.3. Economic Impact of Flooding 4

2. RECOMMENDED MANAGEMENT MEASURES **5**

2.1. Timeframe for Implementation 5

2.2. Flood Modification Measures 5

2.2.1. Trunk Drainage Upgrade – Boundary Street (FM - RB01) 6

2.2.2. Trunk Drainage Upgrade – Boundary Street to Weigall Sportsground (FM - RB02) 6

2.2.3. Taylor Street to Boundary Street (FM – RB04) 6

2.2.4. Victoria Street South (FM – RB05) 7

2.3. Response Modification Measures 7

2.3.1. Variable Message Display (RM-RB01) 7

2.3.2. Evacuation Planning (RM – RB02) 8

2.3.3. Public Information and Raising Flood Awareness (RM – RB03) 8

2.3.4. Local Flood Plan and DISPLAN (RM – RB04) 8

2.4. Property Modification Measures 9

2.4.1. Flood Planning Levels (PM – RB01) 9

2.4.2. Investigate Flood Proofing (PM – RB02) 9

2.4.3. Voluntary Purchase (PM – RB03) 10

2.4.4. Development Control Planning (PM – RB04) 10

2.5. Recommended Management Measures – Table 11

3. ACKNOWLEDGEMENTS **13**

4. REFERENCES **14**

LIST OF TABLES

Table 1: Hazard Classification 3
Table 2: Estimated Combined Flood Damages for Rushcutters Bay Catchment 4
Table 3: Recommended Management Measures ..... **Error! Bookmark not defined.**

LIST OF FIGURES

Figure 1: Study Area
Figure 2: Peak Flood Depth - 1% AEP Design Flood Event
Figure 3: Peak Flood Depth - PMF Event
Figure 4: Hazard Categories - 1% AEP Design Flood Event
Figure 5: Hazard Categories - PMF Event
Figure 6: Short Term Flood Risk Mitigation Options
Figure 7: Long Term Flood Risk Mitigation Options

FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Flood Prone Land Policy, the management of flood liable land remains the responsibility of local government. The NSW Government, and administered through the Office of Environment and Heritage (OEH), provides financial assistance and specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Australian Government may also provide financial assistance in some circumstances.

The Flood Prone Land Policy provides for specialist technical and financial support to Councils by the NSW Government through the stages set out in the "Floodplain Development Manual – the management of flood liable land, NSW Government, 2005". This Manual is provided to assist Councils to meet their obligations and responsibilities in managing flood liable land. These stages are:

1. ***Flood Study***
   - Determine the nature and extent of the flood problem.
2. ***Floodplain Risk Management Study***
   - Evaluates management options for the floodplain in respect of both existing and proposed development.
3. ***Floodplain Risk Management Plan***
   - Involves formal adoption by Council of a plan of management for the floodplain.
4. ***Implementation of the Plan***
   - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Rushcutters Bay Catchment Floodplain Risk Management Plan constitutes the third stage of this management process. This plan has been prepared by WMAwater for the City of Sydney (Council) under the guidance of Council's floodplain management committee (Committee). This plan provides the basis for the future management of those parts of the Rushcutters Bay catchment which are flood liable and within the City of Sydney local government area.

EXECUTIVE SUMMARY

The recommended Floodplain Risk Management Plan for Rushcutters Bay catchment has been prepared in accordance with the NSW Floodplain Development Manual (Reference 1) and:

- Is based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land; and
- Provides a long-term path for the future development of the floodplain.

The Rushcutters Bay catchment is located 2 km east of the Sydney Central Business District (CBD), in the City of Sydney Local Government Area (LGA). The 90 hectare catchment is fully urbanised, with runoff in the catchment draining to Rushcutters Bay via the area's pit and pipe stormwater system. There are significant overland flowpaths in the catchment, which are active when the capacity of the pit and pipe network is exceeded. Flood liability exists across the area, including locations where overland flow is trapped by unrelieved depressions in the catchment topography, and where overland flow has hazardous depth and velocity.

The Rushcutters Bay Catchment Floodplain Risk Management Study (Reference 2) undertook a detailed assessment of flood risk in the catchment. The assessment included a description of flood hazard in the catchment, as well as an estimate of the economic impact of flooding. The study gave a description of the flood emergency response arrangements in the area, as well as a review of the flood planning level and flood planning area.

The floodplain risk management study also included an investigation of possible options for the management of flood risk in the area. These included structural works, such as drainage upgrades and overland flowpaths, as well as planning measures and SES-related actions. The measures were assessed for their ability to reduce flood risk while also considering their economic, social and environmental impact. A multi-criteria matrix assessment was used to directly compare the options. Of the options investigated, 12 were recommended for implementation, with a priority and time frame assigned to each.

1. FINDINGS OF FLOODPLAIN RISK MANAGEMENT STUDY

1.1. Background

The Rushcutters Bay catchment is located 2 km east of the Sydney CBD and lies within the City of Sydney LGA. The catchment has an area of approximately 90 hectares and includes parts of Potts Point, Elizabeth Bay, Kings Cross, Darlinghurst, Paddington and Rushcutters Bay (refer Figure 1). The area has been extensively developed for urban usage, with a mix of medium to high-density housing and mixed commercial/residential lots, with commercial premises concentrated along Oxford Street and in Kings Cross. There is limited open space in the area, with Rushcutters Bay Park and Weigall Sportsgrounds near the catchment outlet, and a number of much smaller parks scattered through the area.

The catchment drains to Sydney Water's major trunk drainage system, taking flow from the upper regions of the catchment to Sydney Harbour at Rushcutters Bay. The catchment's main trunk drainage line runs along Boundary Street and then McLachlan Avenue, which corresponds with part of the western boundary of the study area. The area's trunk drainage system is linked to Council's feeder drainage system consisting of covered channels, in-ground pipes, culverts and kerb inlet pits. Downstream of New South Head Road there is an open channel that connects the trunk drain to the outlet in Rushcutters Bay.

A number of locations within the catchment are flood liable. This flood liability mainly relates to the nature of the topography within the study area as well as the capacity of service provided by drainage assets. Urbanisation throughout the catchment occurred prior to the installation of road drainage systems in the 1900s and many buildings have been constructed on or adjacent to overland flow paths or in unrelieved sags. Due to these drainage restrictions, topographic depressions can cause localised flooding as excess flows have no opportunity to escape via overland flow paths. This creates a significant drainage/flooding problem in many areas throughout the catchment.

The Rushcutters Bay Catchment Flood Study (2013) was carried out to define existing flood behaviour for the Rushcutters Bay catchment in terms of flood levels, depth, velocities, flows, hydraulic categories and provisional hazard. The 1% AEP peak flood depth is shown on Figure 2, while Figure 3 shows the Probable Maximum Flood (PMF). As can be seen on Figure 2, there is significant overland flow in large flood events, with over 1 m of water in several areas, including the unrelieved depressions in Sturt Street and Victoria Street. Figure 4 and Figure 5 show the hazard categories for the 1% AEP and PMF events respectively. Areas of high hazard in the catchment generally correspond to the major overland flowpaths, with the majority of high hazard along Boundary Street and McLachlan Avenue.

1.2. Flood Hazard Classification

Classification of flood hazard in the catchment was based on a combination of the provisional flood hazard categories and a range of other factors that are not captured by the provisional

categories. These factors include, but are not limited to: rate of rise of floodwater, duration of flooding, community awareness and effective warning time. A qualitative assessment of these factors was undertaken, the results of which are summarised in Table 1. The provisional hazard categories complement this assessment, as they delineate areas of the floodplain where the depth or velocity of floodwaters is considered hazardous.

Table 1: Hazard Classification

Criteria	Weight [1]	Comment
Size of the Flood	Medium	Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation.
Depth & Velocity of Floodwaters	High	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event.
Rate of Rise of Floodwaters	Medium	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events.
Duration of Flooding	Low	The greater the duration of flooding the more disruption to the community and potential flood damages. Permanent inundation due to sea level rise is of indefinite duration.
Flood Awareness and Readiness of the Community	Medium	General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent, event.
Effective Warning & Evacuation Time	Medium	This is dependent on rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act.
Effective Flood Access	Medium	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication.
Evacuation Problems	Low	The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and ongoing bad weather conditions is a consideration.
Provision of Services	Low	In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones. Permanent inundation from sea level rise may lead to permanent loss of services.
Additional Concerns	Low	Floating debris, vehicles or other items can increase hazard. Sewerage overflows can occur when river levels are high preventing effective discharge of the sewerage system.

[1] Relative weighting in assessing the hazard for the Rushcutters Bay catchment

Detailed description of the flood hazard classification is given in Section 3.3 of the Rushcutters Bay Catchment Floodplain Risk Management Study.

1.3. Economic Impact of Flooding

The economic impact of flooding in Rushcutters Bay catchment was assessed as part of the floodplain risk management study. Damages were calculated for residential and commercial/industrial properties, based on a floor level survey of properties inundated in the 1% AEP event. The flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account flood damages to any basements or cellars, hence where properties have basements damages can be under estimated.

The damages assessment found that 37 properties within the catchment are liable to over floor inundation in the 1% AEP event, while 19 properties are liable in the 5 year ARI event. The assessment estimated the average annual damage to be approximately $2.1 million for the catchment. Table 2 gives the estimated tangible damages for the catchment (both residential and commercial/industrial properties)

Table 2: Estimated Combined Flood Damages for Rushcutters Bay Catchment

Event	Number of Properties Flood Affected	No. of Properties Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
PMF	200	119	$ 11,558,600	$ 57,800
0.2%	156	55	$ 6,640,100	$ 42,600
1%	145	45	$ 5,434,200	$ 37,500
2%	137	41	$ 4,861,800	$ 35,500
5%	131	35	$ 4,248,900	$ 32,400
10%	117	23	$ 3,155,500	$ 27,000
20%	110	17	$ 2,570,300	$ 23,400
50%	92	14	$ 2,141,100	$ 23,300
Average Annual Damages (AAD)			**$ 1,967,900**	**$ 9,800**

Detailed description and results of the damages assessment is given in Section 5 of the Rushcutters Bay Catchment Floodplain Risk Management Study.

2. RECOMMENDED MANAGEMENT MEASURES

The Rushcutters Bay Catchment Floodplain Risk Management Study made a full assessment of the existing flood risk in the catchment. Based on this assessment of flood risk, the study investigated a range of management measures for the area, which can be categorised as Response Modification Measures, Property Modification Measures and Flood Modification measures, as per the NSW Floodplain Development Manual (Reference 1). Measures were assessed for their efficacy across a range of criteria, which allowed them to be compared against one another and their overall effectiveness ranked. Measures which improved the management of flood risk in the catchment were selected and form the primary content of this Plan.

The measures have been categorised by their type (Response, Flood or Property) and given a priority ranking. The ranking is based upon a combination of reduction in flood risk, ease of implementation, cost/funding implications and outcomes based on the multi-criteria matrix assessment (refer Section 9.5 of the Study). More information on each measure is available in the Floodplain Risk Management Study, including discussion of its implementation and its effect on the existing flood behaviour.

2.1. Timeframe for Implementation

Floodplain management measures recommended by this Plan have been assigned a timeframe for implementation, in order to form short term, medium term and long term strategies for the area's floodplain management. Use of different timeframes ensures that priority is given to those measures which can be undertaken in the near future, while also retaining less feasible options for long term implementation.

Short term measures are those that are able to be implemented in the next 1-10 years, and are comprised of response modification and property modification measures, while medium term refers to a 10-20 year timeframe. Long term measures are those that have greater constraints (usually financial or logistical) and are therefore planned to be implemented in the next 20-50 years. As discussed in the floodplain risk management study, the structural options for the Rushcutters Bay catchment have numerous technical constraints and are all costly, despite some having favourable benefit-cost ratios. For this reason, options that do not have benefit-cost ratios greater than 1 should be undertaken in conjunction with other infrastructure works (for example, road upgrades) that mitigate their constraints.

The following section includes both a priority and a designated timeframe for each recommended management measure. Short term measures are shown on Figure 6, while Figure 7 shows the long term measures.

2.2. Flood Modification Measures

The following sections detail the flood modification measures recommended for implementation in the catchment. Figure 7 shows the location of the options in the catchment. It should be noted that three of the four options (FM-RB01, FM-RB02 and FM-RB04) entail the same drainage

upgrades on Boundary Street, and are presented here as alternatives to each other. As all of the options presented are considered feasible, they have each been recommended as part of this Plan.

2.2.1. Trunk Drainage Upgrade – Boundary Street (FM - RB01)

Option FM – RB01 entails an upgrade of the trunk drainage system along Boundary Street and Neild Avenue, in order to reduce the high hazard overland flow in the area. The option, which involves upgrading the capacity of the pit and pipe system, and re-grading some sections, has been shown to reduce most areas of high hazard flow to low hazard in a 10% AEP event, and also reduce property inundation.

Although the measure produces a range of benefits to the area's flood risk, it involves large capacity upgrades and a large outlay. The benefit-cost ratio of the option is 1.7, which indicates that the measurable economic benefit of the upgrade will more than offset the cost of the works.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

2.2.2. Trunk Drainage Upgrade – Boundary Street to Weigall Sportsground (FM - RB02)

As with the previous option, option FM – RB02 entails an upgrade of the trunk drainage system along Boundary Street, in order to reduce the high hazard overland flow in the area. The option, which involves upgrading the capacity of the pit and pipe system, and re-grading some sections, has a similar benefit to FM-RB01, with reduced areas of high hazard flow and improved property inundation. It exists as an alternative measure to FM-RB01.

Like FM-RB01, the option requires large capacity upgrades and a large capital outlay. The benefit-cost ratio of the option is 2.2, which indicates that the measurable economic benefit of the upgrade will more than offset the cost of the works. Also, the works are contingent on the relevant stakeholders accepting the minor increase in flooding on Weigall Sportsground.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

2.2.3. Taylor Street to Boundary Street (FM – RB04)

Option FM – RB04 is a combination of the trunk upgrade described by FM-RB02 with drainage upgrades in the Taylor Street area, as well as an upgraded trunk drain along Boundary Street to Barcom Street and Oxford Street. It is aimed at both alleviating the flood issue at Boundary Street (high hazard flow and property inundation) as well as that near Taylor Street (property inundation). The option has been shown to achieve both of these objectives. As it overlaps with areas proposed

for upgrade under FM-RB01 and FM-RB02, it exists as an alternative to these options.

The significant benefits produced by the option are offset by the large capacity upgrades it requires and the associated capital outlay. The benefit-cost ratio of the option is 0.9, which indicates that the measurable economic benefit of the works is slightly less than their cost. As with FM-RB02, the works are contingent on the relevant stakeholders accepting the minor increase in flooding on Weigall Sportsground.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its financial feasibility, benefit cost ratio and associated technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

2.2.4. Victoria Street South (FM – RB05)

Option FM-RB05 entails an upgrade of the trunk drainage at the southern end of Victoria Street, in order to reduce the ponding that occurs in front of one entrance of St. Vincent's Private Hospital. The option, which involves a new drainage pipe along Victoria Street, has been shown to largely remove the ponding in a 10% AEP event, and reduce the ponding to low hazard in the 1% AEP event. The hospital is not flooded above floor in a 1% AEP event.

The feasibility of the option is limited by the fact that the existing flood issue is not severe. Although the hospital is a critical facility, the ponding does not occur at the emergency entrance, and there is another entrance to the private hospital nearby. Also, the required drainage element is large and would require a significant financial outlay. The option's B/C ratio has not been assessed as the upgrade has minimal effect on property inundation.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its financial feasibility and associated technical issues. The measure is recommended to be implemented by City of Sydney in the long term.

2.3. Response Modification Measures

2.3.1. Variable Message Display (RM-RB01)

Variable message displays can be used on main roads to warn motorists and pedestrians of a flood that is occurring. The hazardous nature of flooding on a main road can be underestimated in an urban area, where ponding of floodwaters may appear innocuous. When depths of flooding are greater than 0.3 m and it becomes dangerous for vehicles to cross them, it will be necessary to provide a detour around the flooded area. The variable message displays are aimed at reducing the number of people who enter floodwaters by warning of the conditions and recommending an alternative route.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its benefit to the SES and its relative ease of application. The measure is recommended to be implemented by City of Sydney and Roads and Maritime Services (RMS) in the short term.

2.3.2. Evacuation Planning (RM – RB02)

Significant property inundation in a rare flood may force residents to evacuate their homes. Residents will either leave of their own accord, as they feel their property is uninhabitable, or they will be issued an evacuation order. The SES has responsibility for evacuating people due to flooding. The sudden nature of flooding in the catchment means little to no warning is available for a flood event, and so the evacuation would almost certainly take place during or after the storm event.

There are a number of issues associated with evacuating, mostly relating to the additional hazards arising from leaving one's home, and the risk to the rescuers, that mean evacuation should generally not be undertaken in the Rushcutters Bay catchment. However, the process should be planned for (likely in a DISPLAN prepared for the area) in case evacuation is required.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations. The measure is recommended to be implemented by City of Sydney and the SES in the short term, likely as part of other emergency response arrangements.

2.3.3. Public Information and Raising Flood Awareness (RM – RB03)

High flood awareness in a community reduces the damage and disruption during and after a flood event. Flood awareness includes knowledge of the range of floods that can occur and with what frequency, and what should be done during and after a event to minimise the flood risk and its disruption. When there is a transient population of residents and commercial operators, for example in inner Sydney, awareness can be promoted through a public information programme. There are a number of tools available to disseminate information on flooding, including letters from Council, historical flood markers and articles in local newspapers.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations and risk to life. The measure is recommended to be implemented by City of Sydney in the short term.

2.3.4. Local Flood Plan and DISPLAN (RM – RB04)

As mentioned previously, it may be necessary for some residents to evacuate their homes in a major flood. This would usually be undertaken under the direction of the lead agency under the DISPLAN, the SES. Some residents may choose to leave on their own accord based on flood information from the radio or other warnings, and may be assisted by local residents. The main problems with all flood evacuations are;

- They must be carried out quickly and efficiently;
- There can be confusion about 'ordering' evacuations, with rumours and well-meaning advice taking precedence over official directions which can only come from the lead

agency, the SES;
- They are hazardous for both rescuers and the evacuees;
- Residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers, and
- People (residents and visitors) do not appreciate the dangers of crossing floodwaters.

For this reason, the preparation of a DISPLAN and a Local Flood Plan helps to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. It is the role of the SES to develop these plans for vulnerable communities.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on SES operation in the catchment and the resultant reduction in flood risk. The DISPLAN is recommended to be prepared by the SES in the short term, while the Local Flood Plan is recommended to be prepared in the same time frame by the SES, with City of Sydney responsible for supplying the required data.

2.4. Property Modification Measures

2.4.1. Flood Planning Levels (PM – RB01)

The flood planning level (FPL) is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in the flood affected areas must be built. The FPL includes a freeboard above the design flood level. It is common practice to set minimum floor levels for residential buildings, garages, driveways and even commercial floors as this reduces the frequency and extent of flood damages. Freeboards provide reasonable certainty that the reduced level of risk exposure selected (by deciding upon a particular event to provide flood protection for) is actually provided.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its economic merits. A review of the FPLs put forward by Council in their *Interim Floodplain Management Policy* (Reference 4) was carried out as part of the Floodplain Risk Management Study and it was recommended that case studies be provided to illustrate how these levels could be applied to individual developments to assist in development applications.

2.4.2. Investigate Flood Proofing (PM – RB02)

Flood Proofing involves the sealing of entrances, windows, vents, etc., to prevent or limit the ingress of floodwaters. It is only suitable for brick buildings with concrete floors and can prevent ingress for outside depths of approximately one metre. Greater depths may cause collapse of the structure unless water is allowed to enter.

Preliminary assessment has indicated that flood proofing is a good solution to reducing flood risk to commercial and industrial properties. Based on previous experience, the option can be cost-

effective relative to drainage upgrades or other structural works, and easier to implement. Further assessment should be undertaken to ascertain the depth of ponding that flood proofing can protect against, what types of properties can be flood-proofed, the variation in cost for different cases, where responsibility lies for carrying out and funding the works, and any associated risks with the approach.

The measure has been given high priority in the Floodplain Risk Management Plan, based on the number of properties it can benefit and its economic merits. Investigation is recommended to be undertaken by City of Sydney in the next 12 months.

2.4.3. Voluntary Purchase (PM – RB03)

Voluntary purchase involves the acquisition of flood affected residential properties (particularly those frequently inundated in high hazard areas). Although it conventionally involves demolishing the house to remove it from the high hazard flow, there is also an opportunity for the existing structure to be flood-proofed and kept on. This conventional approach of removing the house is not considered necessary for the Rushcutters Bay catchment. However, it may be possible to modify the approach and purchase properties situated on high hazard overland flowpaths, carry out floodproofing works on them, and then re-sell them. It is recommended that the feasibility of such an approach be investigated to determine its cost, associated benefits and possible risks.

The measure has been given medium priority in the Floodplain Risk Management Plan, based on its potential to aid flood-affected properties. Investigation is recommended to be undertaken by City of Sydney in the next 1-2 years.

2.4.4. Development Control Planning (PM – RB04)

The catchment's location in inner Sydney means there is continuing pressures for both redevelopments of existing buildings as well as for new developments. The strategic assessment of flood risk can prevent development occurring in areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce the potential damage to new or redeveloped properties likely to be affected by flooding to acceptable levels.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its financial feasibility. Recommendation for an update of the planning documents (i.e. Sydney DCP 2012 and Sydney LEP 2012) has been discussed in the Floodplain Risk Management Study in order to inform of the development controls as published in the Interim Floodplain Management Policy (Reference 4). Inclusion of these provisions would ensure that the controls can be enforced which also take into consideration the potential impact of climate change. The update is recommended to be implemented within City of Sydney in the next 12 months.

2.5. Recommended Management Measures – Table

The recommended measures described in the previous sections are summarised in **Error! Reference source not found.** in order of priority. The table provides a reference point for the Plan's recommendations, and represents one of the main outcomes of the floodplain risk management process for the Rushcutters Bay catchment.

Through the flood mitigation option development process, at some locations more than one option has been tested for the mitigation of flood risk. These will tend to have some variance in their impact, so for example Boundary Street flooding is reduced by both FM – RB01 and FM-RB02, with the latter having a slightly different alignment. Nevertheless, in most cases it may be that one of these options is preferred for implementation rather than both.

However, given the scale of these works and the fact that their feasibility and eventual cost will be significantly impacted by existing services, further analysis is required prior to a decisive selection being made. This analysis should focus specifically on feasibility of construction and if feasible, cost estimates should then be estimated by a quantity surveyor. It is recommended that the further feasibility analysis is carried out when appropriate capital available is available for the works.

Table 3 Recommended Management Measures

REF[1]	MEASURE	PURPOSE	PRIORITY	RESPONSI-BILITY	TIME FRAME	COST
RM-RB04	**Local Flood Plan and DISPLAN for the Sydney East Emergency Management District**	Formalise emergency response arrangements for the area, including evacuation procedures.	High Priority	SES (Plans) and City of Sydney (Data)	Short term	Internally within SES and Council
PM-RB02	**Investigate flood proofing for its feasibility across varied buildings types and flooding behaviour.**	Reduce the damages of flood affected properties by preventing ingress of floodwaters.	High Priority	City of Sydney	Short term	Internally within Council
RM-RB01	**Use of Variable Message Displays on affected roads as part of emergency response arrangements**	Improve public awareness during a flood event, reduce number of vehicles entering hazardous ponding	High Priority	City of Sydney and RMS	Short term	Internally within Council and RMS
PM-RB04	**Update Sydney DCP 2012 and LEP 2012 based on FRMS&P outcomes and to inform of Council's Interim Floodplain Management Policy**	Prevent development occurring in high hazard areas or impacting existing flood behaviour	High Priority	City of Sydney	Short term	Internally within Council
PM-RB01	**Review FPLs following completion of FRMS&P for Rushcutters Bay catchment.**	Reduce the damages of flood affected properties by having elevated floor level	High Priority	City of Sydney	Short term	Internally within Council

REF[1]	MEASURE	PURPOSE	PRIORITY	RESPONSI-BILITY	TIME FRAME	COST
RM-RB03	**Develop ongoing flood awareness and public information programmes for the area**	Increase community's awareness during and after a flood event to reduce damages and risk to life	Medium Priority	City of Sydney	Short term	Internally within Council
RM-RB02	**Evacuation planning (may be included in the area's DISPLAN and Local Flood Plan.)**	Minimise the risk associated with evacuations, determine when evacuation is required	Medium Priority	City of Sydney and SES	Short term	Internally within Council
PM-RB03	**Investigate the feasibility of a voluntary purchase scheme that includes flood proofing affected properties**	Reduce the damages of flood affected properties via flood proofing	Medium Priority	City of Sydney	Short term	Internally within Council
FM-RB02	**Boundary Street trunk drainage upgrade from before the intersection of McLachlan Avenue, down Neild Avenue**	Reduce hazardous overland flowpath, reduce risk to affected properties	Medium Priority	City of Sydney	Long term	Approx. $5,578,100 capital, $5,300 ongoing (annual)
FM-RB01	**Boundary Street trunk drainage upgrade from before the intersection of McLachlan Avenue, down part of Neild Avenue, outlet into Weigall Sportsground**	Reduce hazardous overland flowpath, reduce risk to affected properties	Medium Priority	City of Sydney	Long term	Approx. $7,515,000 capital, $7,500 ongoing (annual)
FM-RB04	**Trunk drainage upgrade on Sims, Taylor, Sturt Streets, down Boundary Street up to Weigall Sportsground**	Reduce hazardous overland flowpath, reduce risk to affected properties	Low Priority	City of Sydney	Long term	Approx. $15,987,900 capital, $17,100 ongoing (annual)
FM-RB05	**Pipe and drainage upgrades along Victoria Street**	Reduce ponding in front of critical facility	Low Priority	City of Sydney	Long term	Approx. $1,178,200 capital, $11,700 ongoing (annual)

[1]Reference of measure in the Rushcutters Bay Catchment Floodplain Risk Management Study

3. ACKNOWLEDGEMENTS

WMAwater wish to acknowledge the assistance of the City of Sydney Council staff and the Floodplain Management Committee in carrying out this study as well as the NSW Government (Office of Environment and Heritage) and the residents of the Rushcutters Bay catchment. This study was jointly funded by the City of Sydney Council and the NSW Government.

4. REFERENCES

1. NSW Government (2005) Floodplain Development Manual – the Management of Flood Liable Land, Department of Infrastructure, Planning and Natural Resources

2. WMAwater (2015), Rushcutters Bay Catchment Floodplain Risk Management Study, Draft Report

3. WMAwater (2013), Rushcutters Bay Catchment Flood Study, Draft Report

4. City of Sydney (2014), Interim Floodplain Management Policy

Figures


FIGURE 1
RUSHCUTTERS BAY
STUDY AREA
N
Study Area
Pits
Pipe/Culvert Width/Diameter (m)
0.1 - 0.45
0.45 - 0.75
0.75 - 1.0
1.0 - 2.4
2.4 - 3.8
0
0.25
0.5
km
J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure01 Study Area RB.mxd


FIGURE 2
RUSHCUTTERS BAY
PEAK FLOOD DEPTH
1% AEP EVENT
Billyard Ave
Onslow Ave
Ithaca Rd
Elizabeth Bay Rd
Evans Rd
Amos Lne
William St
Darlinghurst Rd
New South Head Rd
Surrey St
Liverpool St
Burton Street
Liverpool St
Crown St
Bourke St
Eastern Distributor
Glenmore Rd
Albion St
Oatley Rd
Moore Park Rd
Leinster St
Watson St
Gordon St
Study Area
Depth (m)
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.0
> 1.0
0
0.25
0.5
km
J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure02 PeakFloodDepth 100y RB.mxd

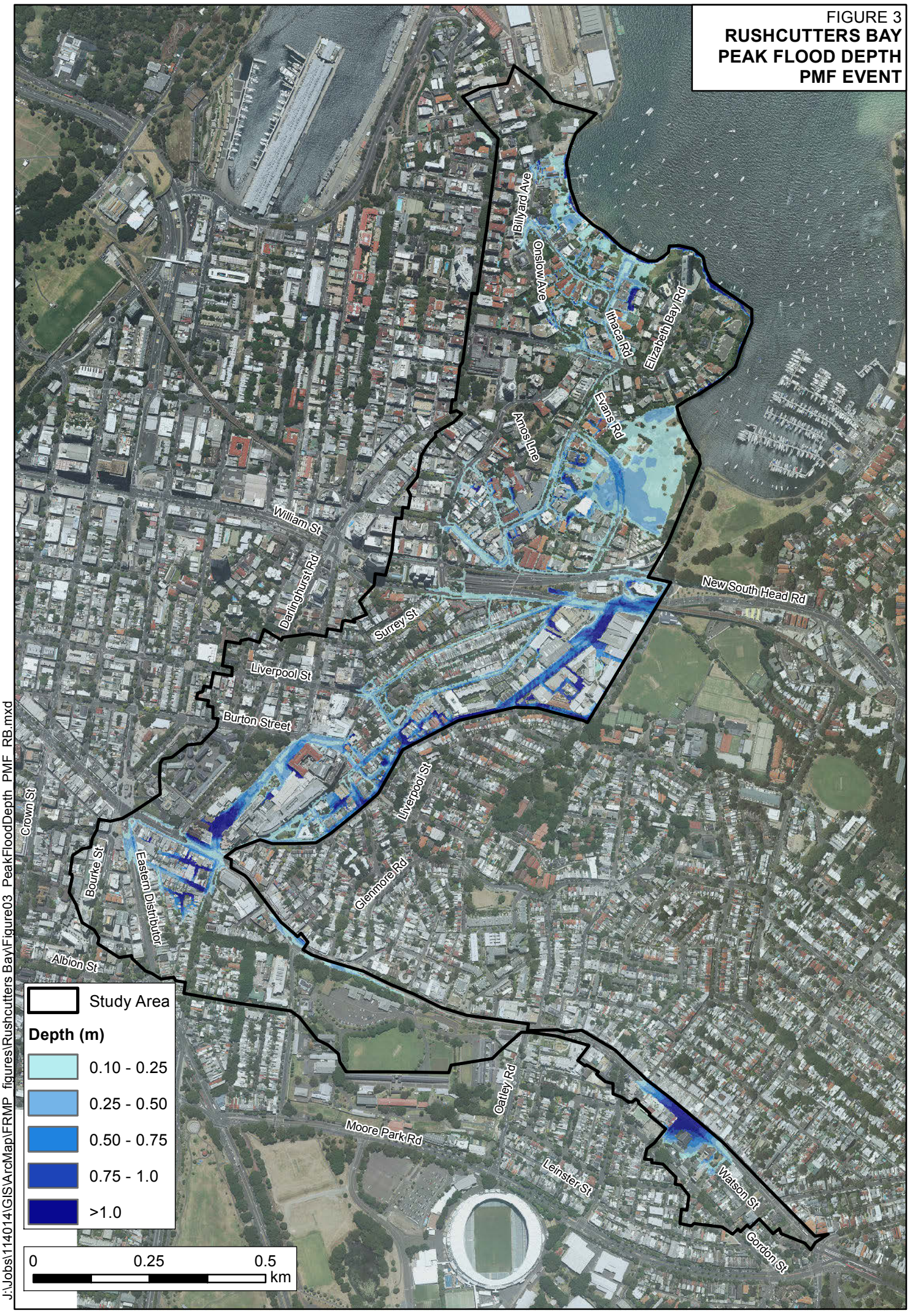


FIGURE 3
RUSHCUTTERS BAY
PEAK FLOOD DEPTH
PMF EVENT
Billyard Ave
Onslow Ave
Ithaca Rd
Elizabeth Bay Rd
Evans Rd
Amos Lane
William St
Darlinghurst Rd
Surrey St
New South Head Rd
Liverpool St
Burton Street
Liverpool St
Crown St
Bourke St
Eastern Distributor
Glenmore Rd
Albion St
Oatley Rd
Moore Park Rd
Leinster St
Watson St
Gordon St
Study Area
Depth (m)
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.0
>1.0
0
0.25
0.5
km
J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure03 PeakFloodDepth PMF RB.mxd

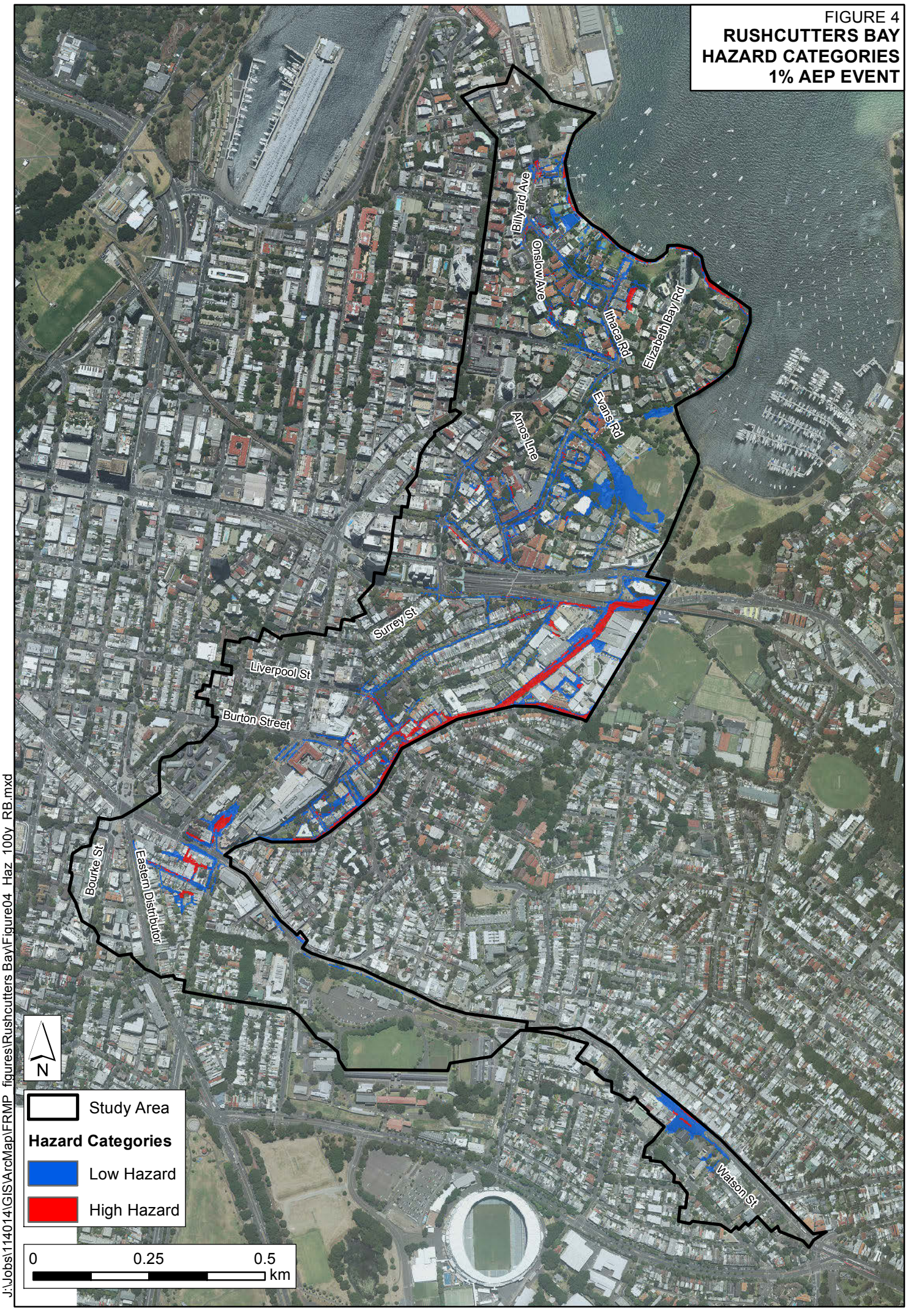


FIGURE 4
RUSHCUTTERS BAY
HAZARD CATEGORIES
1% AEP EVENT
Billyard Ave
Onslow Ave
Ithaca Rd
Elizabeth Bay Rd
Evans Rd
Amos Lne
Surrey St
Liverpool St
Burton Street
Bourke St
Eastern Distributor
Watson St
N
Study Area
Hazard Categories
Low Hazard
High Hazard
0
0.25
0.5
km
J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure04 Haz 100y RB.mxd

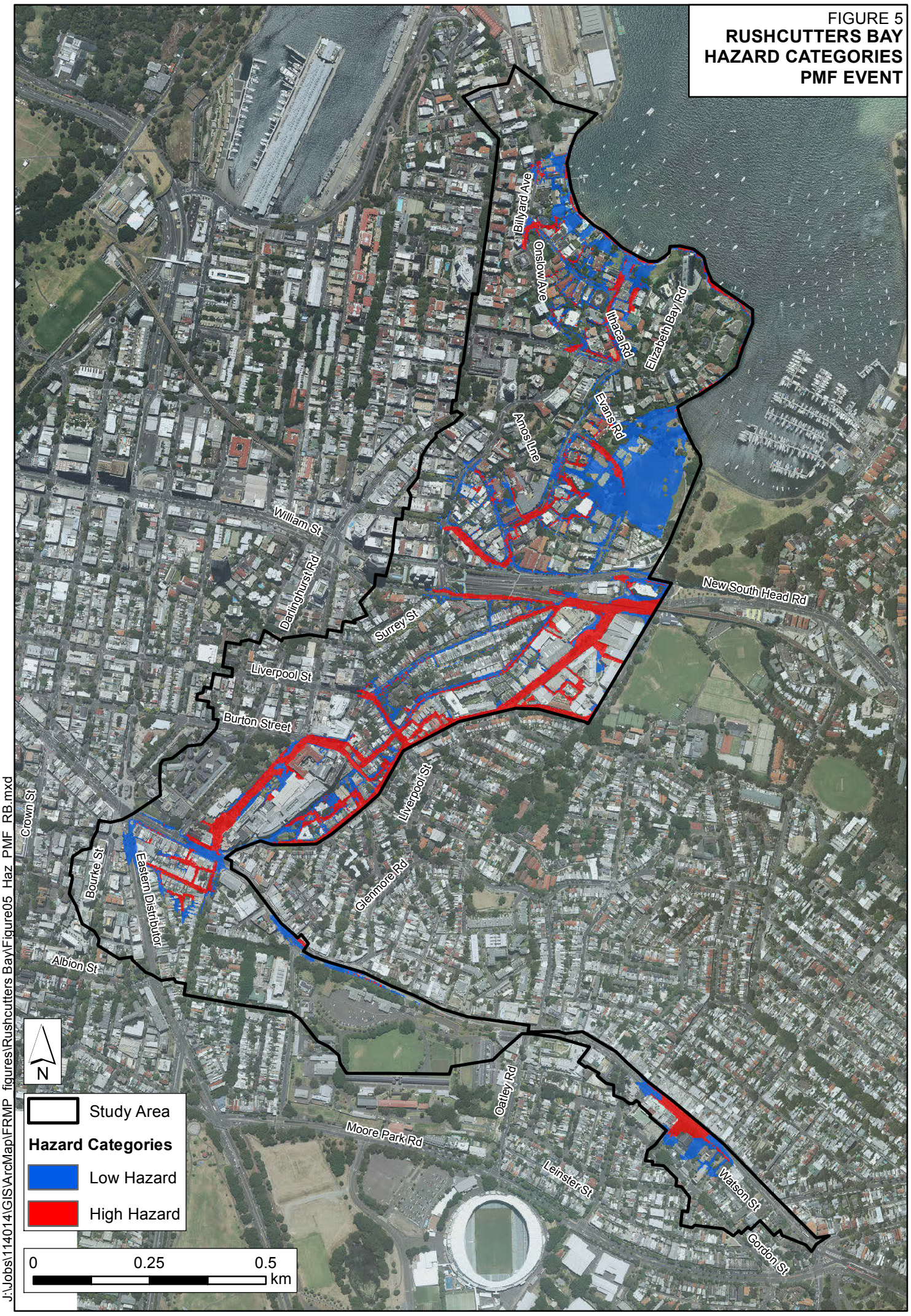
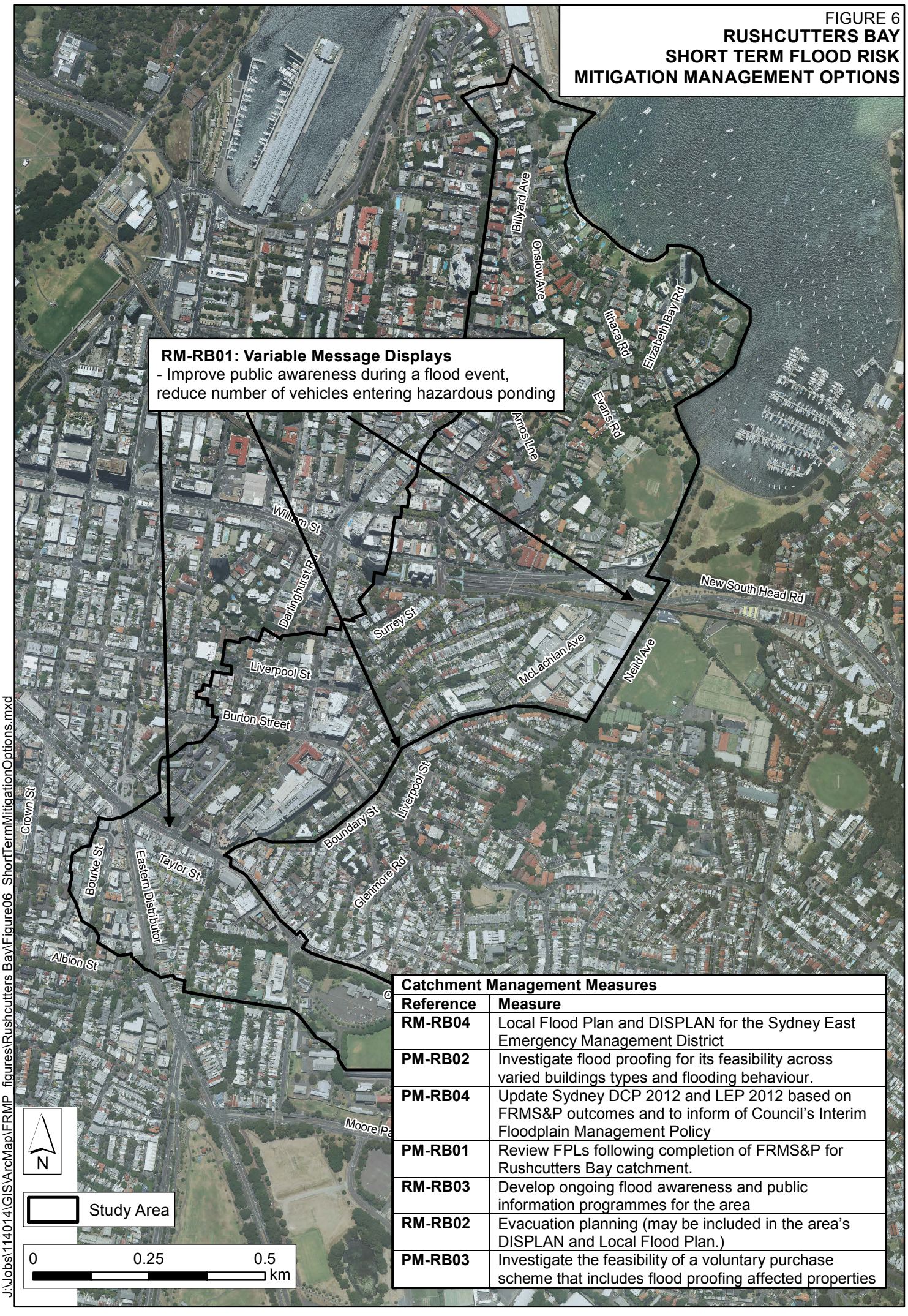


FIGURE 5
RUSHCUTTERS BAY
HAZARD CATEGORIES
PMF EVENT
Billyard Ave
Onslow Ave
Ithaca Rd
Elizabeth Bay Rd
Evans Rd
Amos Lne
William St
Darlinghurst Rd
New South Head Rd
Surrey St
Liverpool St
Burton Street
Liverpool St
Crown St
Bourke St
Eastern Distributor
Glenmore Rd
Albion St
Oatley Rd
Moore Park Rd
Leinster St
Watson St
Gordon St
N
Study Area
Hazard Categories
Low Hazard
High Hazard
0
0.25
0.5
km
J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure05 Haz PMF RB.mxd

FIGURE 6

RUSHCUTTERS BAY SHORT TERM FLOOD RISK MITIGATION MANAGEMENT OPTIONS

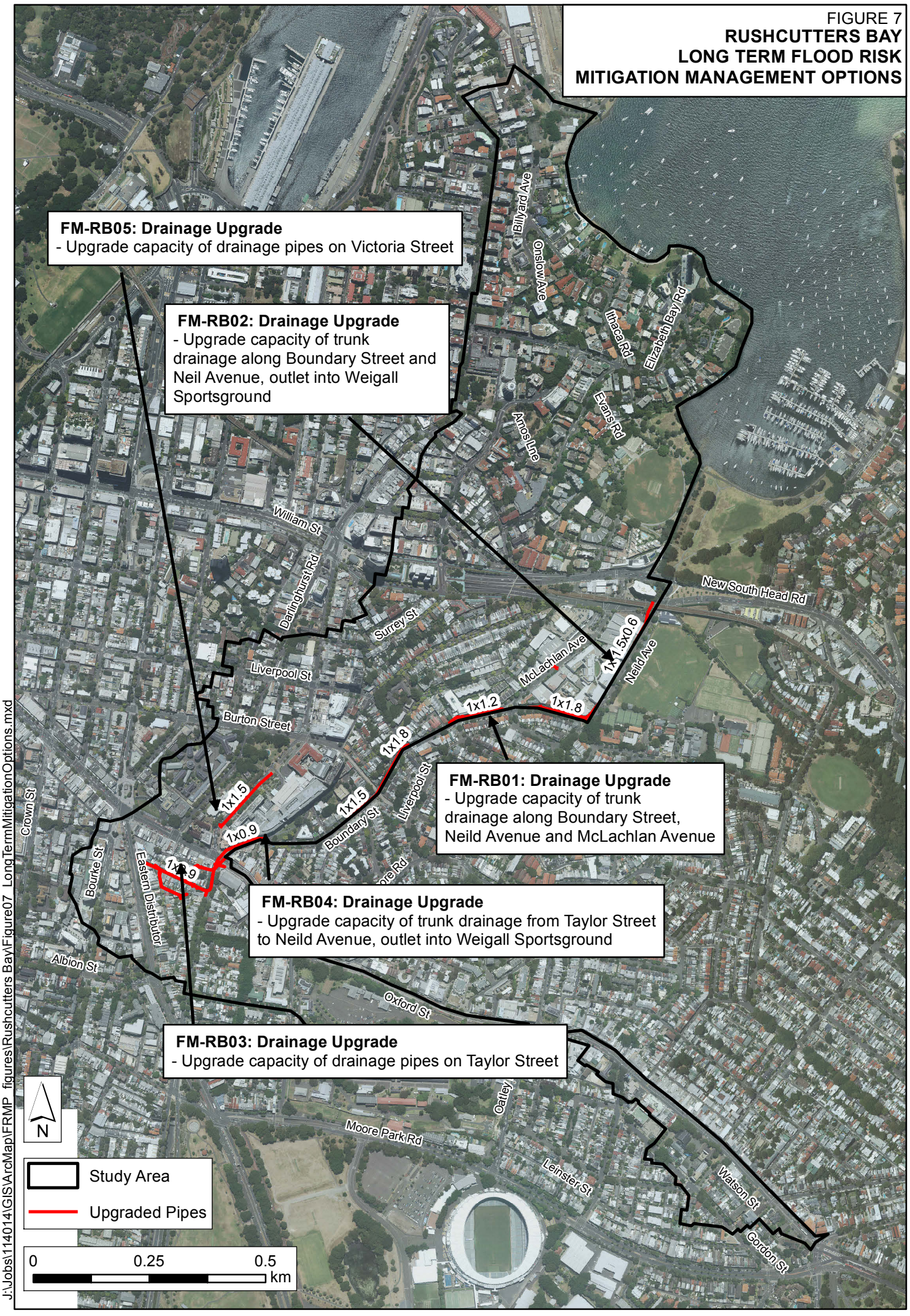


Catchment Management Measures	
Reference	**Measure**
RM-RB04	Local Flood Plan and DISPLAN for the Sydney East Emergency Management District
PM-RB02	Investigate flood proofing for its feasibility across varied buildings types and flooding behaviour.
PM-RB04	Update Sydney DCP 2012 and LEP 2012 based on FRMS&P outcomes and to inform of Council's Interim Floodplain Management Policy
PM-RB01	Review FPLs following completion of FRMS&P for Rushcutters Bay catchment.
RM-RB03	Develop ongoing flood awareness and public information programmes for the area
RM-RB02	Evacuation planning (may be included in the area's DISPLAN and Local Flood Plan.)
PM-RB03	Investigate the feasibility of a voluntary purchase scheme that includes flood proofing affected properties

J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure06_ShortTermMitigationOptions.mxd

FIGURE 7

RUSHCUTTERS BAY LONG TERM FLOOD RISK MITIGATION MANAGEMENT OPTIONS



J:\Jobs\114014\GIS\ArcMap\FRMP figures\Rushcutters Bay\Figure07_LongTermMitigationOptions.mxd